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ABSTRACT

The strong potential of videodisc technology for improving the education of the hearing impaired is described in this report on the Media Development Project for the Hearing Impaired (MDPHI) at the University of Nebraska. The topics covered include: (1) the history of the use of technology in deaf education; (2) the history of videodiscs and their capabilities; (3) a comparison of the optical and capacitance systems of videodiscs; (4) an overview of the systems currently being produced; (5) a description of the instructional design, development, and evaluation efforts carried out by MDPHI on videodisc technology for deaf education; and (6) the production techniques used to edit and caption videodiscs. Extensive bibliographies are included after each chapter. (BK)

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Videodisc: An Instructional Tool for the Hearing Impaired

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Table of Contents

Chapter 1
Introduction and Background 1

Chapter 2
Videodisc History and Capabilities 7

Chapter 3
The MDPHI Videodisc Project 19

Chapter 4
Designing Videodisc Instruction 25

Chapter 5
Videodisc Production 39

Videodisc: An Instructional Tool For The Hearing Impaired

CHAPTER 1: Introduction and Background

A. TECHNOLOGY AND THE EDUCATION OF THE DEAF

"the deaf American"...

Educators generally agree that nothing thwarts the acquisition of language as much as a hearing loss. Deafness disrupts the basic communication processes of mankind which in turn limits the educational levels to which a deaf individual can rise. Available figures indicate that only 34.7 percent of the deaf population completes twelve years of schooling and only 5.6 percent go on to college. Achievement test data for the same years indicate that only a very small number of deaf students attain the educational level of their hearing peers. The educational deprivations of a hearing impaired population are naturally reflected in their economic status.

With the current emphasis on enriching the educational opportunities for the handicapped, it would seem that one of the top priorities would be a full scale attack on a deaf child's mastery of the English language. One of the major strategies of this massive attack would be the development and application of modern communication technology. For the hearing impaired youngster, technology can possibly provide the verbal input upon which he or she can base a linguistic structure, thus opening the doors of his learning potential.

It may seem a contradiction of sorts to suggest that the technology to be applied to the learning problems of the hearing impaired is the same technology that to a great extent has intensified or aggravated the barriers which separate the hearing impaired from normal society. The telephone, radio, sound films, the phonograph, or audio recordings, television, and other electronic communication devices can all be cited as examples of technology that have vitiated against the deaf individuals communication with the normal population. These techni-

technical barriers...

cal devices have in turn developed many commonplace day-to-day customs and mores that have further intensified the communication problems of the deaf. Some examples of this are two-way radios in cars, music in buses and elevators, hand-held paging systems, talking toys, home inter-coms, and hundreds of similar things. We have, in short, the technology to bring verbal and pictorial messages from Saturn, but lack the ability to bridge the few centimeters of space between a deaf child's eardrum and his Central Nervous System.

Still it is not too remote a possibility that we could use the same technical ingenuity that creates communication barriers to reduce or eliminate them. As we move into the frontiers of space, where without electronic support everyone is deaf, there

may be some technical developments that can be used in closing the communication gap that prevents the hearing impaired from fully participating in American life. Radio waves can transmit a printed page as readily as a voice, and theoretically radio could serve the hearing impaired as well as the non-handicapped. The problem then is not one of invention, but of application.

full participation. . .

In our country an education is not an end in itself but fundamental for competing successfully in an open society. Although the American citizen, by and large, is extremely charitable and doesn't mind lending his hand to his less fortunate brethren, full citizenship requires educational parity. For the handicapped citizen, patronization, condescension or mercy is no longer the ticket. In current policy and legislation the emphasis is on educational equality and that the handicapped are entitled to the full developmenmt of their educational potential. Tapping the potential of communcation technology to meet the educational needs of the hearing impaired is a necessary step toward bringing them into the mainstream of American society.

The matter of exploiting the potential of technology for the benefit of the hearing impaired is one of degree. The hearing impaired have been the beneficiaries of America's technical ingenuity and inventiveness. The near phenomenal improvement in hearing aids and amplification systems is but one of many examples of industry responding to needs. One might also mention that the deaf have been enjoying the benefits of educational and entertainment films that have been captioned for them and captioned television programs are becoming more commonplace. The program for the 1980 Symposium on the Research and Utilization of Educational Media for Teaching the Deaf is possibly an indicator that media is already one of the major strategies for educating the hearing impaired.

The phenomenal growth and diversity of TTY equipment for telephone services is yet another example of a technical response to the needs of the hearing impaired.

One can go a bit further and mention some of the developments still at an experimental level of usage but with great future potential. We have the means today to bring to the hearing impaired citizens of this country verbal and pictorial information that is nothing short of phenomenal. It is pertinent to briefly describe some of this potential.

new communication technology. . .

1. With Line-21 captioning it is now technically feasible to bring to hearing impaired television viewers the verbal information that typically is delivered via the sound track. Most people are unaware of the extent to which the sound track is the prime message carrier in a television production and therefore do not comprehend the hollowness of a picture without verbal support. This captioning development alone will provide a deaf person with verbal input which evaded him/her previously.

2. It is beyond ordinary comprehension to grasp the massive amount of data and verbal information that is stored in American computers. Almost anything one could conceivably want to know in any field of human endeavor can be extracted from a computer system somewhere. The hearing impaired student, instead of being limited to the knowledge he can acquire from his immediate family and a handful of teachers now has access to the sum total of man's knowledge. This may not seem like a magnificent breakthrough for a handicapped population whose predominant learning characteristic is a difficulty in dealing with language. However, with the latest potential that

exists within this technology one could possibly provide a hearing impaired student with all the language stimuli he needs to overcome his deficit.

3. The third development, videodisc, is perhaps a simple combination of items one and two above; that is a visual display combined with computer assisted instruction. The capability of the videodisc in educating the hearing impaired will be discussed in the ensuing chapters. For the present it will suffice to say that it can be a significant factor in the reduction of communication barriers that separate the hearing impaired from normal society.

The above are but a few of the communication capabilities whose potential exists and whose potential is waiting to be applied. Further down the road are even more astonishing developments.

federal legislation. . .

Recent legislation, such as PL 94-142, makes it mandatory that handicapped learners be provided equal opportunity to develop their full educational potential. Furthermore, the Rehabilitation amendments, 503 and 504, address discrimination in the world of work. The same stress and support for elimination of architectural barriers is being applied to the reduction of communication barriers. Conditions for reducing the educational gap that separated the handicapped from the normal population were never more favorable.

A reader of current educational literature should be very much aware that our educational system has become the scapegoat for societal ills. As a syndicated newspaper article recently stated (Omaha World Herald September 5, 1979), "American public education is caught between a rock and a hard place." Familiar charges are: Johnny can't read; there's no discipline; teachers aren't doing their jobs; and similar charges. Despite the fact that we spend less on schools than on liquor there seems to be a growing belief that the taxpayer isn't getting his money's worth from public education. In various ways there has been a steady erosion of public support for our educational institutions despite the fact Americans firmly believe that a high level of literacy is fundamental to a democratic society.

support for education. . .

The ills that are befalling general education are having similar ramifications in Special Education. The difference, if any, is one of degree, and one of the compounding factors in the education of the handicapped is the condition of rising expectations in the face of eroding fiscal support. We are faced with the incongruity of doing it better and doing it more cheaply. This is particularly true in the education of the hearing impaired where the considerable support for mainstreaming is based on the fact that it is less costly.

Teaching the hearing impaired is possibly the most difficult task in the entire educational scene. There may be a number of reasons for this but the predominant one is the fact that knowledge is packaged for transmission by a verbal medium. With his/her linguistic deficit, the deaf student is an enormous challenge. A by-product of this difficulty is that educational services for the hearing impaired are very expensive. A residential school may spend as much as $15,000 per year on the education of deaf children; yet the results are disappointingly short of our expectations, particularly when viewed solely from the perspective of achievement scores.

However, if one wishes, there are other comparisons which put our deaf population in a better light. While our American educational system may have some flaws, it is still the best in the world. Deaf Americans are preeminent in the world by most indicators of success. They are competitive in the job market, capable of handling their own affairs, participating in

careers and professions, and obtaining degrees in higher education.

What this adds up to is a picture of an educational system that has both strengths and weaknesses. In the application of educational technology this may be typified by the situation in which we have nearly 1,000 educational film titles captioned for the hearing impaired. The flip side of this coin is that this is but a small fraction of all available titles. The

resources. . .

same can generally be said of much of the effort being made on behalf of the hearing impaired. The ideal situation is when there are absolutely no restrictions on the resources that a hearing impaired student needs, but reality dictates that the absolute cannot be attained. The reasonable compromise is that the role of educational technology be constantly evaluated and redefined.

Because of the fact that the costs of educational materials for the hearing impaired must be prorated over a relatively small population the economics of assisting the deaf learner are not favorable. The usual formula for establishing cost effectiveness for instructional materials are: learning effectiveness and low cost and a large population. Materials for the hearing impaired must rely on only two of these variables. Since modern communication technology is becoming more extensive every day, the major factor in justifying materials for the hearing impaired is dependent upon the condition of effectiveness.

This will serve as a basis for justifying the efforts of a national center in meeting the technology needs of the hearing impaired.

B. THE ROLE OF THE MEDIA DEVELOPMENT PROJECT FOR THE HEARING IMPAIRED

In 1964, an idea involving the use of 8mm sound/color cartridge-loaded films to assist in teaching speechreading to hearing-impaired students led the way for the establishment of several successive centers at the University of Nebraska--Lincoln. These centers explored and demonstrated the potential contributions of educational technology in educating the acoustically handicapped student.

The original experimental project resulted in a grant to produce an additional 100 short 8mm continuous loop films which had been designed to assist the deaf student in learning to speechread 330 nouns that a survey identified as being essential vocabulary for the first year of formal schooling (kindergarten). Completion of this project led to the formation of a Media Center at the University of Nebraska--Lincoln, its goal being to work exclusively with the problems of instructional communication for the deaf learner.

media center. . .

Continued federal support, in 1966, resulted in the establishment of the Midwest Regional Media Center for the Deaf (MRMCD). A special additional grant that year funded the first Educational Media Institute for Teachers of the Deaf. This Institute, for graduate credit, was conducted annually through 1973. From 1966 through 1974 the Center provided numerous workshops and conferences aimed at improving education for the deaf and hard of hearing. The design and production of instructional materials based on student needs was emphasized at these conferences which were attended by teachers, media specialists, and administrators from programs for the deaf all over the country.

The concepts behind these basic media institutes were further promulgated through a regional inservice program conducted by the Center. The Center's staff and media instruction personnel provided service and instruction throughout a 12-state region, reaching over 1,000 educators in 27 school programs.

Meanwhile, the work of film development for the deaf which began in 1964 continued. Many pilot films were tested in programs for the deaf and subsequently duplicated for mass distribution. For more specific information about MRMCD activities see the October 1974 issue of the American Annals of the Deaf.

specialized office. . .

In September, 1974, the U.S. Office of Education's Bureau of Education for the Handicapped, through the Learning Resource Branch, awarded the Specialized Office for the Deaf and Hard of Hearing to the University of Nebraska--Lincoln. This change allowed the Center to intensify its efforts in locating and adapting existing educational materials for the deaf. The Specialized Office, through contacts with 1,700 publishers, screened 5,000 specimens of instructional materials annually, evaluating them for their suitability in teaching the deaf. By the end of the three-year project over 15,000 reviews were coded and entered into the computer base at the National Instructional Materials Information System (NIMIS), Ohio College Library Center. This information is now in the computer system of the National Information Center for Special Educational Media (NICSEM), University of Southern California.

During this 1974-1977 period the Specialized Office for the Deaf and Hard of Hearing was also involved in some product adaptation and development activities. A cooperative arrangement with the Southwest Iowa Learning Resources Center in Red Oak was established to modify 24 vocational exploration/awareness packages. These self-help media kits are now being marketed as a Special Educational edition of Project Discovery. Also during the Specialized Office phase the Project provided assistance to the Office of the Los Angeles County Superintendent of Schools to complete an Auditory Skills Instructional Learning System. This was a set of materials to improve listening skills of hearing impaired children.

The present Media Development Project is one of two national media development centers designated by the Bureau of Education for the Handicapped, U.S. Office of Education, for education of the handicapped through media and other resources. The other national media project is responsible for developing materials pertinent to the severely and profoundly handicapped.

The Media Development Project for the Hearing Impaired, established in September 1977, has three major areas of responsibility: Instructional Information and Search; Instructional Media Design and Modification; and Materials Evaluation.

Contributions of the current project in terms of national impact are:

project functions. . .

1. Hearing impaired students (age 3-21) will benefit from specifically designed instructional materials that have been adapted or newly developed to serve their identified learning needs.

2. Cooperative development/evaluation/dissemination efforts between this project and other federally funded agencies serving the hearing impaired will result in appropriate, better, and more functional instructional materials/media and technology reaching all hearing impaired students throughout the United States.

3. Administrators, supervisors, media specialists, and directors of educational programs serving the hearing impaired will be kept informed of current ideas and implementation procedures for instructional materials/media technology through an annual Symposium.

The Media Development Project for the Hearing Impaired is a unique organization which has as its major objective the acceleration and improvement of learning opportunities for the deaf learner. The project focus is on developing, modifying, producing, and evaluating suitable learning materials for those students who have a hearing deficiency. A by-product of this project is the location of gaps that currently exist in curriculum materials and resources.

videodisc technology. . .

The Media Development Project for the Hearing Impaired serves a leadership role in advocating the use of educational media and technology in teaching the deaf student. In this role it is not a coincidence that MDPHI has become involved in the development of videodisc materials for teaching the deaf. The videodisc is a medium that offers great promise to the education of the deaf. It can serve as an interactive device to involve the student in his or her learning experience. It offers even greater potential when coupled with a computer memory to recall, branch, search, identify, and sequence learning elements.

The following chapters will describe the history and functions of videodisc technology, the program objectives of MDPHI, the instructional design aspects of videodisc programming, and finally the description of some significant production strategies.

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CHAPTER 2: Videodisc History and Capabilities

EARLY HISTORY

In 1927 John Logie Baird, a British television pioneer, demonstrated that video signals could be stored on an ordinary phonograph record and the first "video disc" was born. Unfortunately, the technology of that period did not permit production of a very clear picture and Baird's research was dropped (Lachenbruch, 1974). But the dream of combining audio and video signals on a record-like platter persisted and became a reality 23 years later through the efforts of a company formed by Telefunken and British Decca Records. TelDec, the first successful videodisc system developed, was demonstrated publicly in Berlin in 1970. Playing time on these initial discs was only five minutes, but both audio and video quality were high.

Other companies were also experimenting with the new technology and in 1972 Music Corporation of America (MCA) demonstrated its first videodisc system. The following year the Dutch firm, N. V. Philips, began demonstrations of its system throughout Europe. And in 1973 Thomson-CSF, a French company which had begun videodisc development in 1971, signed a technical information exchange agreement on videodiscs with Zenith Radio Corporation (Lachenbruch 1974). By 1974 videodisc development was in full swing. The Journal of the Society of Motion Picture and Television Engineers devoted the bulk of its July issue to articles about disc technology that year. Although different systems had slightly different capabilities, they were all touted as high density storers of information which could play back material in a variety of formats. Other advantages included the ability to play one specific part without having to play everything preceding it (random access) and the relatively cheap costs of mass reproduction and distribution. The videodisc was being called "the next step in the communications evolution" (Kreiman, 1974, p. 553).

The situation was not all one might have hoped for, however. Although at least ten companies were known to be developing videodisc hardware at this time, none were compatible (Petras, 1974, Lachenbruch, 1974). All were designed to play color pictures and stereo sound through the transfer of information on disc into electronic pulses which could be reproduced through a standard television set. But they all achieved this transfer of information in different ways.

Optical vs Capacitance

Basically, the various approaches can be broken into the optical systems and the capacitive systems, although at least one firm tried a magnetic system. The optical videodisc players use a laser or some other light source to read information encoded in microscopic pits on the disc's surface. The light beam is focused onto the disc's surface and either bounces back off a reflective surface or passes through a transparent disc to a detector. As the light strikes the information pits the beam is interrupted and this modulation is translated into the television signal. Because nothing comes in contact with the disc, its playing life is theoretically indefinite. [Fig. 1] The capacitive, or mechanical, players read the changes in an electronic signal which passes between an electro-conductive plastic disc and a metal face on a phonograph-like stylus. Pits in the disc's surface cause changes in the distance

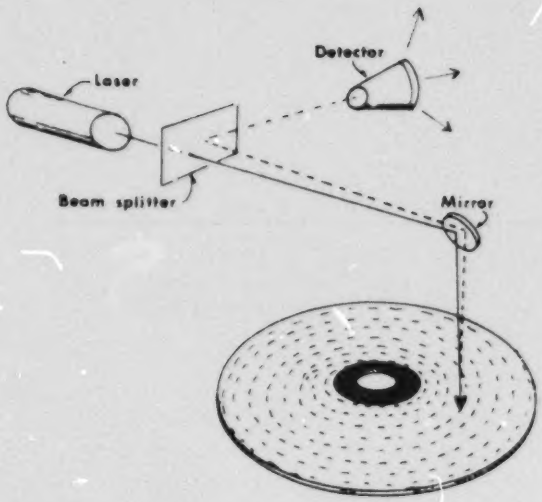


Figure 1

The MCA/Philips videodisc system bounces a laser beam off the information pits on the videodisc. Since there is no physical contact with the disc, there is no wear and the light beam can move quickly and easily from any one spot to any other.

between these two surfaces which create a change in the electronic capacitance. Because a stylus maintains physical contact with the disc both the stylus and disc have limited life spans, which vary depending on the system. [Fig. 2] The main advantage of this system is that it is technically less complex.

Philips and MCA were both optical systems with playing time of 30 minutes. They were similar in both principles and results, except that the MCA disc originally played from the outside in, like an audio record, while the Philips disc played from the inside out. The Thomson-CSF and Zenith systems were also optical, but whereas Philips and MCA used reflective laser systems, Thomson and Zenith used transmissive systems. Both had playing times of 20-25 minutes. Three other optical systems in development were based on photographic film principles and used standard photo printing techniques in disc duplication. These were i/o Metrics, Optidisc and Digital Recording Company. The latter system was the only one in which the disc remained still while the scanning system moved.

TelDec was a capacitive system. Playing time had been increased to ten minutes and a changer model was being developed to play multi-disc sets. The system was due to be introduced in Germany during the summer of 1974, with marketing in the U.S. later that year, but some problems were discovered with the paper sleeve in which

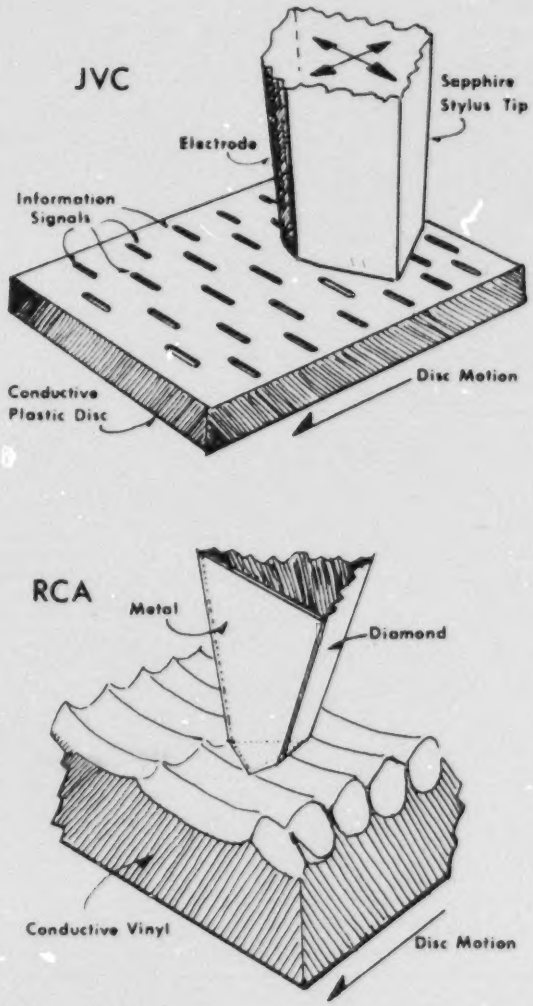


Figure 2

The JVC videodisc system uses a broad stylus tip, which reduces wear on the discs. The information is encoded in pits similar to the optical systems and the grooveless disc design permits the stylus to cut across the tracks for random access.

The RCA videodisc system uses a diamond stylus in a grooved track, similar to audio records. This method eliminates the possibility for random access and also makes still framing and slow motion impossible. It is, however, less expensive.

12

the disc was enclosed and marketing was postponed. A second capacitive system was developed by Radio Corporation of America (RCA) with a playing time of 30 minutes. This was the only system in which each frame was not recorded in one revolution of the disc and therefore the only system without the possibility of freezing on a single frame or playing the disc in slow motion.

The third type of videodisc system, magnetic, was tried with the MDR, or magnetic disc recorder. This was essentially like videotape except it used a rotational piece of tape instead of linear tape. It was also the only videodisc system designed for home recording as well as playback.

Japan had not yet produced any videodisc systems, but rumors ran rampant. Sanyo and Matsushita Electric were reportedly developing disc systems (Petras, 1974) while Pioneer Electronics was more interested in manufacturing equipment developed by one of the other firms.

Public Demonstrations

In 1975 the videodisc battle went public and it looked like consumers would soon have a choice of systems to add to their home entertainment areas. MCA and Philips had joined forces the year before and were ready for their first public demonstration of the MCA/Philips DiscoVision system in March, 1975, with plans to begin regional marketing in 1977. The players were capable of fast forward and reverse motion as well as variable slow motion and the individual display of single frames. These simple to operate, yet durable, players were expected to sell for around $500 (Schmedel, 1975). The 30-minute discs were recorded on only one side. Less than a week after the MCA/Philips demonstration RCA held the first public demonstration of its SelectaVision system. Although SelectaVision did not have the same capabilities as DiscoVision, RCA believed the consumer was interested in a cheaper, simpler and potentially more reliable product. Except for the pick-up arm, every part of the RCA player was a standard part already in mass production, whereas the laser, lens and other parts of the MCA/Philips player were not yet in mass production. RCA expected its players to sell for around $400 and the discs would have two half hour sides.

During the same week that MCA/Philips and RCA demonstrated their videodisc systems in New York City, TelDec made its marketing debut in Europe. The players cost $650 and each 10-minute disc cost $4.30. The response was less than enthusiastic and sales were poor. I/O Metrics, the only other system shown publicly that year, had not been able to produce a satisfactory monochrome picture and began to slip from sight.

compatibility. . .

Zenith and Thomson-CSF continued to work together on a system almost compatible with MCA/Philips. In fact, a Zenith-made disc was played on the DiscoVision player during the New York demonstration. Later that year, Zenith/Thomson initiated compatibility talks with MCA/Philips in the first overt act of concern about standardization of videodisc systems. In a report on the March demonstration, Gerald M. Walker (1975) wrote, "Actually, both Philips and RCA engineers concede it is technically possible to make the two systems compatible, but neither is willing to devote the time or the money to do so" (p. 72).

As a result of the compatibility talks, Zenith signed an agreement with MCA and Philips in 1976 for a compatibility standard. Since that time the company has officially been fence-sitting and watching developments in the continuing videodisc drama. Thomson-CSF, on the other hand, decided to stick with its transmissive videodisc and did not sign the compatibility agreement. As a result, it began test marketing its disc system the following year, with plans to

tackle the consumer market in the early 1980's.

differences. . .

The differences between the Thomson-CSF and MCA/Philips systems involved more than whether the laser beam passed through the disc (transmissive) or reflected off it (reflective). Because the system was transmissive, the Thomson-CSF disc was transparent and by refocusing the light both sides could be played without turning over the disc. This meant it was less sturdy and needed to be packaged in a protective plastic cartridge, but Thomson-CSF hoped the flexible discs could eventually become magazine supplements. The biggest and most significant difference, however, was that while all the other systems were designed primarily for home entertainment, Thomson-CSF was aiming its videodisc systems at the educational and industrial market. Indeed, the first players off the production line in 1977 were destined for such large French companies as Renault. In addition to the frame by frame viewing, variable slow motion, freeze framing, random access, and two audio channels of the MCA/Philips system, Thomson-CSF also included a microprocessor. This made the estimated price of the system nearly three times as high as the RCA or MCA/Philips systems, but it also made the videodisc potentially interactive.

The potential for providing interactive or nonlinear program capabilities with an optical videodisc system was also seen by MCA. In mid-1977 MCA and Pioneer Electronic Corporation established a joint corporation in Japan, Universal Pioneer, to develop and make videodisc players, the initial products of which would be designed for the industrial market. These educational/industrial (E/I) players would include microprocessors capable of memory storage, parts for external computer hook-up and remote control units and would make interactive branch programming feasible on an economic basis (Cavanagh, 1977). According to Jack Findlater, head of MCA DiscoVision, the E/I player "was independently developed by MCA as a new communications tool. It's specially designed for instruction, for training, for high-density storage and retrieval of all types of information" (Smith, 1979, p. 22).

Other events of 1977 included RCA's field testing of its SelectaVision system and Matsushita's announcement of the development of its relatively simple capacitive videodisc system, Visc II. The disc would be stamped in poly-vinyl chloride like a regular LP and would play for one hour on each side. Supposedly the Visc II system would play RCA discs and the RCA player could play Visc II discs if they were pressed on the conductive plastic used by the RCA system (Anderson, 1978). Matsushita did not indicate when they would enter production, as they still needed to line up disc manufacturers and program material. By 1978 the entrants in the videodisc race were narrowed down to TelDec, RCA, MCA/Philips, Thomson-CSF and Matsushita. Matsushita was only beginning to make public demonstrations and TelDec which had lost its early momentum, was "being written off as a factor by many in the industry" (Gerson, 1976, p. 40). The two leading contenders were generally agreed to be RCA and MCA/Philips--one a capacitive system and the other optical.

Early in 1978 RCA demonstrated the latest operating version of its system in New York. Some work still needed to be done on several circuits, but playing time had been increased from 30 minutes to one hour per side and the recording process had been simplified to a single step. By the beginning of the following year the company finally decided to market its SelectaVision system and former NBC president Herb Schlosser was put in charge of software development. It is estimated that the system will be on the market some time during the second half of 1980. RCA is still trying to keep the price under $500.

CURRENT EVENTS
Magnavision Players

When MCA/Philips began test marketing its videodisc player in Atlanta on December 15, 1978, the retail price was $695, and the entire stock was gone in 20 minutes. Some observers were puzzled by the marketing strategy because, although the price was $200 more than estimated, it was $200 less than the estimates of the player's true cost (Business Week, 1978, Wall Street Journal, 1978). Since the initial test marketing in Atlanta, the machines have also become available in Seattle, Dallas, Cleveland, Phoenix, Pittsburgh, Minneapolis and Buffalo. The price climbed to $775 in June, 1979, but because of the short supply some have reportedly been resold at double that price (Wall Street Journal, 1979). The player, known as Magnavision, is made and marketed by Magnavox, a subsidiary of North American Philips Corporation. MCA produces the discs, with playing time now up to one hour per side.

These discs have 54,000 circular tracks per side. When each track contains one single picture frame the disc will play straight through as motion in 30 minutes. On a 60-minute disc the tracks contain more than one frame. This alters the system's capabilities to some extent. A half hour disc on the Magnavision, or home, player is capable of freeze frame, step motion, variable slow motion, fast forward and reverse and search functions. Automatic stops and chapter stops can be added. The use of freeze frames, step motion and slow motion will naturally extend the playing time of a 30-minute disc depending on the extent of their use.

The user can stop and hold any of the 54,000 frames on the videodisc, resulting in what is called a freeze frame. The frame could be one of many in a motion sequence or it could be a single frame designed specifically for use in the freeze frame mode. The process of holding a single frame is accomplished when the player reads the same circular track repeatedly. Since the laser does not touch the disc the frame can be repeated indefinitely

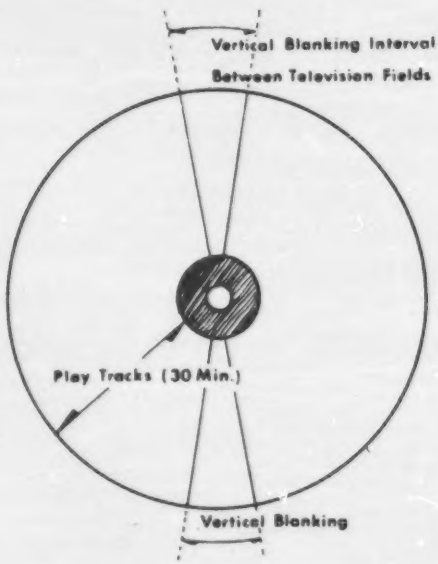
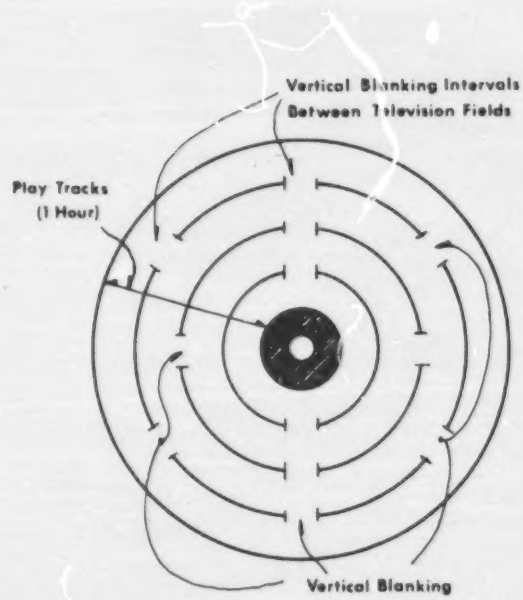


Figure 3

The standard play, or 30 minute, disc maintains a constant motor speed of 1800 rpm while varying the track length for each picture. Each revolution of the disc results in a single picture frame.



The extended play, or 60 minute, disc keeps the track length for each picture constant but varies the motor speed from 600 rpm at the outer edge to 1800 rpm at the inner edge. The number of frames produced by a single revolution of the disc varies as play progresses.

without any harm to either the disc or the player. When the user progresses through the disc one frame at a time, freeze frame after freeze frame, step motion results. This is similar to a filmstrip presentation. Sixty-minute discs are not designed for freeze framing or step motion because, unlike 30-minute discs, each track or revolution does not necessarily contain a single picture. [Fig. 3] On 30-minute discs each picture, or frame, continues for one complete revolution of the disc, regardless of the circumference of that track. Inside tracks are shorter than those on the outer edge, but each still contains only one picture frame. This is not the case with 60-minute discs. In order to fit the additional information on a 12-inch disc, the amount of space containing a single picture frame has been made constant. An inside track might contain a single frame while a track closer to the outer edge could contain three or four. If one complete revolution of an outer track were repeated, as it would be for freeze framing, three pictures might flash repeatedly.

Slow motion in both forward and reverse is also possible with 30-minute discs. And the rate of motion is variable. Each frame is repeated a set number of times before the player moves on to the next frame or track. The number of times the same frame is repeated determines the rate of the slow motion from one frame every four seconds to 30 frames per second, which is the rate of real motion on the videodisc. The function also is not practical with 60-minute discs because multiple images would be repeated.

Three different functions enable the user to access various parts of the disc with relative ease. Fast motion is possible in both forward and reverse at the rate of approximately 90 frames every second, but for even grosser movement the search function will pass over 400 frames every 1/30th of a second. The third method is through the use of chapter stops. These are encoded onto the videodisc in the form of audio signals and when the player is in the chapter stop mode it will automatically stop on these signals.

Automatic stops are similar to chapter stops except that the player will automatically stop on a given frame when it is in the play mode.

In order to locate specific sections of a videodisc or to know one's relationship to the rest of the program, each frame is encoded with an address which can be displayed or removed from the screen at the touch of a button. If the disc has been divided into chapters these numbers can also be encoded. By pressing the button once the user will see the address of the particular frame being viewed, a second push will display the number of the chapter being played, and a third push will erase all numbers from the screen.

The home player also has two audio channels. These can be played together for stereo sound, if stereo speakers are attached, or individually. One channel could be in English while the other was in Chinese, or one channel might contain instructions for the teacher while the other had student instructions. When the player is in any mode other than play, such as freeze frame or slow motion, the audio is automatically removed to avoid distortion.

E/I DiscoVision Players

The E/I version of the DiscoVision system is more versatile than the Magnavision player, although it is similar in many ways. With the additional features mentioned earlier, the system was envisioned primarily for data storage and instruction. The initial players were distributed to government agencies and contractors, but shortly after the model was demonstrated in January 1979, General Motors Corporation bought 7,000 machines for use in showrooms in the United States and Canada.

Discs for the E/I model are 30 minutes long with each frame equivalent to one revolution of the disc. The player has all the capabilities of the home model, except for chapter stops and automatic stop. In exchange, however, it has a microprocessor which is operated through a remote control unit [Fig. 4]. The basic functions can be controlled from either the remote unit or the front of the player itself. (The Magnavision player is controlled from the front of the machine.) But additional functions are operated from the hand held remote control unit.

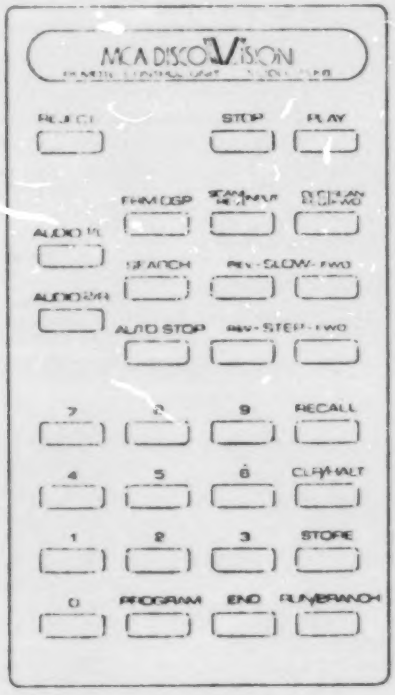


Figure 4

Hand held remote control unit for the MCA DiscoVision E/I videodisc player

One such function is the ability to randomly access any one of the 54,000 frames in less than five seconds. The user enters the address of the desired frame through the numbered keys, followed by the "search" command and the microprocessor will hunt out and display the requested frame almost immediately.

The microprocessor can also be programmed through the remote unit to control the presentation of material on a videodisc. It can be programmed to play segments in any sequence, to branch according to student input, to stop automatically on specific frames and either to hold the frames a predetermined length of time before proceeding or to wait for a command from the user. It can also be programmed to play in any one of the modes previously described. To eliminate the bother of having to program the player every time a disc is played, programming information can be placed at the beginning of the disc during the mastering process. Then every time the disc is played the information will be fed automatically into the microprocessor. And to expand the videodisc's potential for computer assisted instruction beyond the confines of the microprocessor, the E/I player can be interfaced with a computer.

Flexibility is the keystone of the optical videodisc system. Any type of audio visual material, regardless of format, can be transferred to a videodisc and programs can intermix motion and still frames. With a microprocessor computer interface, interactive and nonlinear program capabilities are added.

Recent Developments

But the videodisc story is not finished yet. Matsushita is beginning videodisc production in Japan and Thomson-CSF, RCA and Universal Pioneer all expect to have their players on the market by the mid 1980's. By the late 1980's the Victor Company of Japan (JVC), a subsidiary of Matsushita, plans to market a capacitive videodisc system in the U.S. which will provide variable fast and slow motion, random access and still frame capabilities. And now Atlantic Richfield Development (ARDEV) and Sony have joined the videodisc fray. The ARDEV player may be compatible with Thomson-CSF while Sony expects their player to have compatibility with both

the DiscoVision and Magnavision systems. Sharp Corporation of Japan has expressed interest by signing patent-licensing agreements with MCA, Philips and RCA authorizing it to make and market videodisc players.

On September 5, 1979, a new videodisc venture began when IBM and MCA announced the formation of a joint company, DiscoVision Associates, to develop, manufacture and market videodisc systems. The new venture has taken over MCA's production business for both commercial and industrial discs and will market the industrial players. MCA will continue to handle the distribution of commercial discs. IBM, which has been conducting videodisc research for several years, had been granted two patents on videodisc technology in August, 1979, and had two more pending. The two granted patents deal with increasing the amount of information which can be stored on an optical videodisc (New York Times, 1979) and there is speculation that IBM is more interested in the disc's potential as an information storage and retrieval device than as an entertainment medium (Wall Street Journal, 1979).

However, the entertainment aspects of the technology are not being overlooked. ABC created two new divisions in July, 1979. One will produce movies for theaters, with subsequent use on pay television and videodiscs. The other will assemble old ABC programming as well as produce new material for direct marketing on videodiscs and video cassettes. In January, 1980, CBS signed an agreement with RCA under which they would manufacture videodiscs for the RCA SelectaVision player. Whether this would be only the transfer of existing fare or the creation of new programming specifically for the videodisc market was not announced (Time, 1980). RCA also has an agreement with Paramount to transfer 75 existing films, as well as future releases, to discs. Other companies, including 20th Century-Fox, Columbia Pictures and Allied Artists, have established or acquired new divisions to exploit the potential home video market and Norman Lear's production company has begun development of original programming concepts for home video playback machines (New York Times, 1979).

videodisc recording. . .

Research and development has also begun on videodisc recording systems, although the primary emphasis so far has been for the broadcast industry. Magnetic Disc Recording Company had a magnetic disc system in progress in 1976 which could record two hours of video on each side (Electronics, 1976). The following year Bosch-Fernseh announced the development of a laser picture storage system. Each disc contains 1800 frames or 12 minutes of playing time, and individual frames can be located within one second. RCA also announced a recording system which can store 10,000 frames and has a viewing time of 20 minutes. Like the Bosch-Fernseh system, RCA's is an optical videodisc system using a laser. In fact, it is very similar to the MCA/Philips player except that it has both recording and playback capabilities (Electronics, 1976). Material which is normally stored on magnetic tape, film or slides can be permanently recorded on the system. Random access, freeze frame and search functions will all be possible.

MCA advertises DiscoVision as "the technology of tomorrow, available now." This may be overstating the case somewhat, as advertising wants to do, but the videodisc is certainly an important "next step in the communications evolution" (Kreiman, 1974, p. 553). And because it is an evolution, not a revolution, it is a continuing process. The dream of John Logie Baird over 50 years ago is on the market today.

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CHAPTER 3: The MDPHI Videodisc Project

Since late 1978 the Media Development Project for the Hearing Impaired has been involved in the development, production, and evaluation of videodisc programs for hearing impaired students. Instructional design and scripting have been done by staff from MDPHI; production has been accomplished through the facilities at Nebraska Educational Television. Programs have been produced and mastered for the MCA DiscoVision player.

Israel Videodisc

Discs developed through the MDPHI project have aimed to capitalize on the videodisc's versatility. The first disc uses a multi-media approach in its design. Developed for junior high hearing impaired students, it consists of a unit of instruction designed around a captioned Encyclopaedia Britannica film, "Israeli Boy: Life on a Kibbutz." This disc was basically a reformatting task and was designed to demonstrate the videodisc's capability to combine various media forms into a single format. Included are teacher guide materials, vocabulary instruction, filmstrip-type sequences, and interactive quiz sections. The teacher materials were extracted from the Lesson Guide for Captioned Films and provide objectives, suggested activities, etc. The vocabulary instruction uses visual support to define more difficult words in the film captions. The three filmstrips present instruction in specific areas, the geography of Israel, Jerusalem, and the political situation in the Middle East.

The teacher's guide, filmstrip and quiz sequences are displayed one frame at a time, while the vocabulary and film are played in "real" time to provide motion. The quiz sections are designed for use in either a manual or computer-controlled mode. Students can respond on paper and check their answers from the feedback frame provided, or they can respond using the keyboard of an external microcomputer and be branched either to the next question or to remedial/review sequences should their answer be incorrect. One feature of the quiz is that some questions rely heavily on visual cues. For example, questions about the Wailing Wall use visuals to prompt recognition and understanding.

The multi-media approach used in this disc has certain instructional advantages, but it has economic benefits as well. If purchased separately the film, filmstrips, television, and print materials would cost around $400. The price tag for a disc, however, could be considerably less. The actual cost would depend on the number of discs sold, but there is the potential for substantial savings. There is also the advantage of needing only one piece of equipment for program playback. One videodisc player does the work of a filmstrip projector, film projector, and videocassette machine.

Fingerspelling Videodisc

The second disc developed aims to teach receptive fingerspelling skills to hearing adults through a programmed instruction approach. A task analysis of the content resulted in the identification of a hierarchy or continuum, which prompted the development of approximately 150 sequential motion instructional sequences. Within each sequence a student is presented with a fingerspelled stimulus that requires a covert response. His/her response is then verified through feedback.

The disc is divided into two parts. The first part, visual discrimination, is designed to teach the student to notice differences between word units without looking for individual letters. The student is presented with pairs of fingerspelled words and must decide if they are the same word spelled twice or different words. The second part of the disc aims to teach students how to read fingerspelled words in sentence contexts.

The material is divided into eight sections which must be located using frame numbers, a process similar to using page numbers to locate chapters in a book. Interspersed within the instructions are four quizzes which must be completed with 90% accuracy before the student can proceed to the next section. There is also a comprehensive post-test which covers all disc material.

Instructions are given on print still frames using color-coded backgrounds. Red and green backgrounds are used for directions on operating machine; blue backgrounds provide instructions regarding the instructional sequences.

Video Versatility: The Videodisc for the Hearing Impaired

The third disc is a demonstration illustrating some of the possible applications of videodisc technology in the education of the hearing impaired. It combines materials from previously produced discs, as well as including some new materials. Produced entirely in "real" time, the program describes the videodisc and its capabilities and shows examples related to use with hearing impaired students.

Visual Textbook

Developing a "visual textbook" in the area of high school literature is the approach of another disc. The primary goal of the program is to provide a positive, motivational reading experience for the hearing impaired student through a combination of pictorial and verbal stimuli. The intent is to provide a delivery system that combines the characteristics of a textbook with the characteristics of film and still pictures. The content of the instructional task was broken down into small units that are transmitted via the most appropriate symbol system.

The theme of this disc, entitled By Yourself, is alienation and solitude. Included are a short story, "The Pedestrian" by Ray Bradbury, two short poems, and a song. Appropriate words are highlighted and included with expanded definitions in a glossary section. In each section motion, stills, and print are used singly or in combination to achieve the best advantage. A series of auto stops allows movement from motion into still frame sequences. The instruction is designed for individual, rather than classroom, use since individual utilization more closely simulates textbook reading.

Language and Learning in the Home

One videodisc has been designed for the home player, with an aim to provide parents with materials that can help them foster development and learning in their deaf child. Designed as a part of a larger package of materials, this disc relies heavily on a modeling approach and shows actual hearing impaired children and their parents in typical everyday situations such as sweeping the floor and doing laundry.

Thinking Skills

Two additional discs are intended to promote thinking skills in hearing impaired upper elementary students. The discs will be interactive, with the videodisc player and computer used together to provide computer-assisted instruction. Students will be

branched through the disc according to their pattern of responses.

In each disc a student is presented with a problem which he/she is challenged to solve. As the child works through the disc, he/she receives instruction about various problem solving strategies, such as problem definition and evaluation of solutions. The branching networks include more than one possible solution, so two students may each reach an acceptable, but different, problem solution. The discs aim to teach a systematic approach to problem solving, one which can be generalized to other situations.

These instructional materials integrate visuals from the videodisc and alpha-numerics generated from an external microcomputer. Use of computer-generated print provides greater flexibility and more efficient use of disc space. Changes in wording and placement of the print can easily be initiated should field testing show the need for modification.

Other Videodisc Materials

MDPHI is also using the videodisc as a research tool. One disc is being designed to test various videodisc instructional design strategies for hearing impaired learners. The E/I player is used with an external microcomputer to manipulate organization, pace, and presentation variables.

The final disc scheduled for completion in FY '80 involves an investigation of inserting Line 21, or closed captions, on videodisc. Television material previously produced by the Nebraska ETV Videodisc Project will be encoded with Line 21 captions by the National Captioning Institute. The disc will demonstrate the potential of videodisc to carry closed captions and should isolate any technical problems involved in the encoding process. The disc is entitled "Basic Tumbling Skills" and is designed to help elementary students learn the fundamentals of tumbling.

Evaluation

The first disc was extensively field tested with junior high students and teachers at the Iowa School for the Deaf in the spring of 1979. The aim of the evaluation was to obtain utilization information. The primary question was "Can teachers and students use the videodisc materials in the manner intended?"

The evaluation was designed using two classes of similar ability (average to above-average). Each class contained six students. One class viewed all the materials in a group setting with the teacher operating the videodisc machine (Class I). In the other class, students viewed the motion materials (vocabulary and film) as a group, but worked through the other instructional units individually (Class II). The post-test was shown in the manual mode; students viewed the question frames and responded on paper.

Prior to the evaluation, an in-service was conducted with the teachers to acquaint them with videodisc technology and provide hands-on experience in working with the videodisc player.

Results of the evaluation will be discussed in terms of the questions the evaluation was designed to answer.

1. Do teachers and students have any difficulty in locating and playing various materials on the disc?

   To aid teachers and students in locating the instructional units a chart was prepared that specified the frame numbers and buttons used (Figure 1). With the chart as a guide, students were able to operate the videodisc machine with minimum prompting. They occasionally made errors in entering the five-digit frame numbers, but with brief instruction about the CLEAR button, they were able to correct their mistakes and continue without any

problems.

Typically, the students had less problem with the equipment than did the teachers. Teachers frequently failed to aim the remote control unit at the player and initially had difficulty addressing the instructional units and activating PLAY or STEP FORWARD depending on whether the material was motion or stills. The two teachers in the evaluation appeared to be somewhat intimidated by the player; they were afraid they would "mess it up." Students, on the other hand, seemed to view the remote control unit in the same manner as a hand calculator. They were careful when operating the equipment, but they were not afraid of it.

The evaluation showed that the videodisc can be used successfully for individualized instruction with hearing impaired students. Students can use the machine on their own with a minimum of prompting; they can search out and step through instructional units on the disc. The evaluation also pointed to the need for teachers to have some time to work with the machine on their own. A hands-on in-service serves as a fine introduction, but in order for teachers to feel comfortable with the equipment, they need to have a chance to work with the player without the presence of a media specialist or consultant.

2. What was the student and teacher reaction to the videodisc and videodisc materials?

Students enjoyed operating the player through the remote control unit. When asked if they liked working with the videodisc machine, they all said "yes," and rated their experience the highest possible on the scale used. One class wanted to continue the evaluation another week, even though it involved extensive testing.

Student reaction to the materials was favorable. Their ratings of each of the videodisc materials ranged from a high of 7.75 for the film to a low of 5.73 for one of the filmstrips (9-point scale).

Teacher response to the videodisc was also positive. They liked the multi-media approach afforded by having various materials (film, filmstrip, etc.) on one disc, and they reported that they would use the materials again with a similar class. They perceived the major advantage of the videodisc for the deaf learner to be student and teacher control of the presentation. Students and teachers can stop and/or slow down the presentation to correspond to learning styles.

3. Do the students learn from the materials?

Learning was measured by student responses to the post-test on the videodisc and to other paper-and-pencil tests. Students correctly answered 65% of all test questions (alpha = .69). Highest scores were for one of the filmstrips (average 81%), and lowest scores were for the film (57% average). The two classes scored about equally well on tests over each section of the disc. No statistical tests were run; differences were so small that significance would not have been achieved. In examining the data, however, it was found that on materials which both groups viewed in a class setting, Class I (class viewing) scored higher. Opposite results were found in comparing average class scores over materials which one class viewed individually and one as a whole. The individual viewing situation prompted higher scores.

4. Do any technical difficulties (with the MCA prototype E/I

player) arise when the player is under constant use by teachers and students in classroom situations?

The player was in constant use for 2 days, with no major breakdowns. There was one minor technical problem (PLAY button would not work correctly), which was solved by pushing CLEAR.

Hardware Developments

It became clear early in the project that programming the videodisc through the remote control unit was unrealistic for complex interactive sequences. There were two problems. First, manually programming the disc is a difficult task for program designers, much less teachers and/or students. Second, the MCA player has only 1024 memory locations, each capable of storing a single keystroke. Complex programming sequences can easily exceed this memory capacity.

Since manual programming was unfeasible, the need for an external computer became evident. The result was an interface between the E/I player and the TRS-80 Radio Shack microcomputer. This interface provided 48K memory capacity, and designers were able to plan interactive instructional sequences with complex branching.

Interface with the Radio Shack TRS-80 proved to be only the first step in designing a videodisc/computer system. The second step was a video interface which allowed computer graphics to be superimposed over the videodisc display. This union of computer and videodisc graphics eliminates the need for two display screens, one for the videodisc and one for the computer. Both can now be viewed together on one screen.

Another hardware development resulted from software requirements. An automatic stop function was needed to allow movement from motion into stills. For the E/I player, auto stop can be programmed, but under the present equipment configuration this programming function sacrifices user control. In such cases, the E/I microprocessor controls the playback. If the user chooses to stop, search, or slow down the instruction while the disc is in the program mode, all program functions are lost. In other words, the disc would no longer stop at the next programmed auto stop. To maintain programming functions the user must proceed through the disc according to the predetermined computer program.

Auto stop on the home model, on the other hand, can be achieved by a series of audio tone cues on the disc itself. During program playback the disc will stop when it encounters these cues.

The E/I player does not have this cueing feature. Engineering personnel at Nebraska ETV modified the E/I player so that audio cues can be recorded on the disc and cause the playback to stop. Thus, user control can be maintained.

By the end of September, 1980, which represents the end of the BEH-funded contract, the Media Development Project for the Hearing Impaired will have completed ten disc sides. The ten discs utilize various instructional strategies and capitalize on the videodisc's ability to meet the needs of hearing impaired students. Through careful design of videodisc materials this new technology can perhaps become one tool to help hearing impaired students reach their educational potential.

CHAPTER 4: Designing Videodisc Instruction

A STRUCTURAL FRAMEWORK

Some authors have asserted that current design models do not fully account for the possibilities afforded by videodisc technology (DeBloois, 1979). Our experience with videodisc development has confirmed that design models represent processes, but they do not take into account the more specific structural elements or procedures. Designing videodisc programs involves the same steps as designing any media product. There is a determination of needs, audience analysis, goals and objectives, task analysis, instructional strategies, scripting, and production. Procedural elements, however, must take into account the unique nature of the videodisc; and in determining the instructional strategies and program specifications, the capabilities of the videodisc come quickly into focus.

Videodisc instructional strategies must become multi-dimensional so that a closer match between the instructional method and the needs of the individual learner can be achieved. The many capabilities of the videodisc provide a flexibility in presentation that allows a closer realization of the attribute-treatment paradigm espoused by researchers and developers alike. To reach this goal, designers must consider several questions in selecting appropriate instructional strategies:

1. For what videodisc system will the instruction be designed?
2. Is motion needed?
3. What is the best symbol system or code (digital, iconic, and/or analogue) for each unit of instruction?
4. What degree of linearity in sequencing is needed? Should branching be initiated?
5. Should control of the instruction and sequencing lie with the learner/teacher or computer?

Deciding on the most appropriate symbol system, of course, is a basic decision. With the videodisc we have for the first time a technology that allows us to present all codes in any combination. The designer has the unprecedented opportunity to match the information to be presented with the optimal code. Intuition tells us that some symbol systems are better suited to express some kinds of information than others, but as Schramm (1977) and Salomon (1979) have pointed out, there is only a limited theoretical and research base on which to base such decisions.

Videodisc technology also provides the designer with the option of program/computer or learner controlled instruction. This locus of control ranges from complete control of the sequence by the computer, as specified by the author/designer, to complete control of the sequence by the learner. Because of the low processing intelligence of the Magnavision model and the limited interactive capabilities of the E/I player, instructional design strategies for such systems should emphasize user control. These videodisc systems allow the design of instruction that provides more than the passive learning experience typically encountered with television and film. What the videodisc does is free the user from the tyranny of the clock. If the subject matter requires a variable amount of time depending on the ability of the learner, that time can be created by manually stopping the player until he/she is ready to proceed. Learners can also be given choices by including several instructional sequences and exploiting the disc's two channel

audio and Line 21 capabilities. Teachers and students can have the opportunity to construct their own individualized strategies by selecting those sequences most appropriate to their learning styles and preferences. For example, after completing a unit, they can choose whether to review the sequence, view more examples or practice items, or take a unit quiz.

With computer interface the videodisc becomes more intelligent, and interactive strategies utilizing complex branching and constructed character string responses are possible. Such instruction is generally high in computer control. The computer determines what the student will see and in what order. A high degree of individualization can be achieved, but the programming and branching possibilities are predetermined by the author/designer. The learner interacts with the instruction according to computer instructions, not according to his/her own preferences. Some television systems, including TICCIT (Time-Shared Interactive Computer Controlled Instructional Television), do allow for learner control; but a sophisticated level of programming is required.

Figure 1 is a graphic representation of four structural elements in videodisc design: system configuration, locus of control, linearity of instruction, and still and motion requirements. These elements interact in their influence, and determination of the instructional and authoring strategies must consider the parameters they impose. The systems described are based on the DiscoVision and Magnavision equipment configurations, although instructional capabilities and resulting strategies are similar with other players. The following section discusses strategies appropriate for various levels of videodisc instruction and includes techniques developed by MDPHI staff.

INSTRUCTIONAL AND AUTHORING STRATEGIES

Linear Motion

The simplest level of instruction on the disc would be a straight transfer of existing television or film material. The educational discs currently being marketed by MCA generally fall into this category. There are no still frames; the disc simply plays linearly in real time. Original material designed in this manner utilizes standard television design and scripting methods; no special proce-

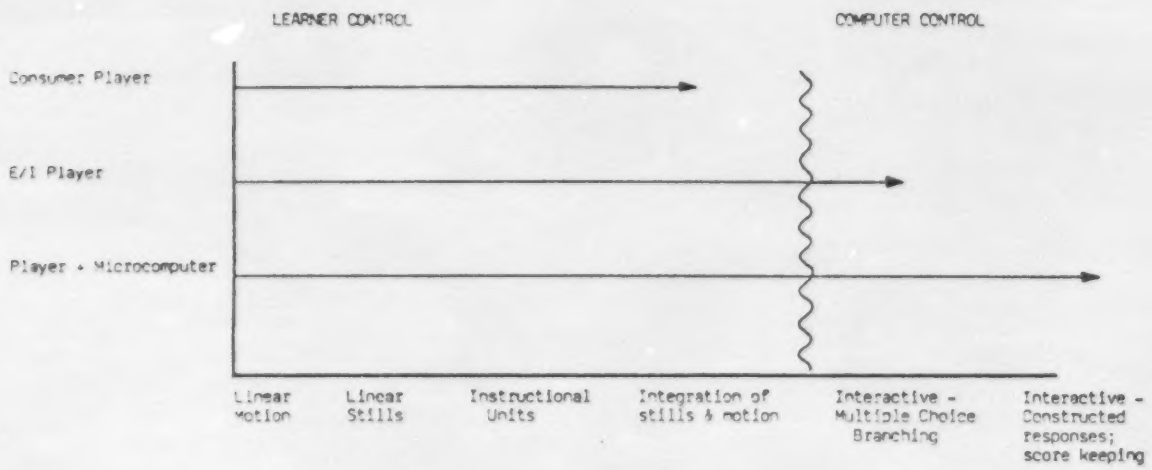

Figure 1

Comparisons of Instruction Available with Various Videodisc Systems

dures are required for the videodisc technology. Producing such material may have distributional advantages, but the instruction does not tap the videodisc's potential.

Linear Stills

The freeze frame capability of the videodisc allows the development of still sequences, but such instruction presents a unique set of constraints. Assembling single frame sequences on disc is difficult and expensive regardless of whether the program is being built on tape or film. (See Chapter 5 for a discussion of editing problems). Also, since there is no audio on still frames, verbal information must be presented in caption form.

One application of still frame capability is storage of information. The videodisc has tremendous information density, but its television display limitations (525 lines) mean that it does not carry large amounts of print well. Anything short of electronically generated print can become illegible. Typed pages using one and one-half to double spacing and sans-serif typeface (i.e. IBM Letter Gothic) can be used for individual viewing situations (Figure 2), but they are unacceptable for group viewing. Videodisc display can be through a cathode-ray tube (CRT), which has higher resolution; but again, there are limitations as to the amount of print that can be displayed. The use of a CRT also limits the visual display possibilities.

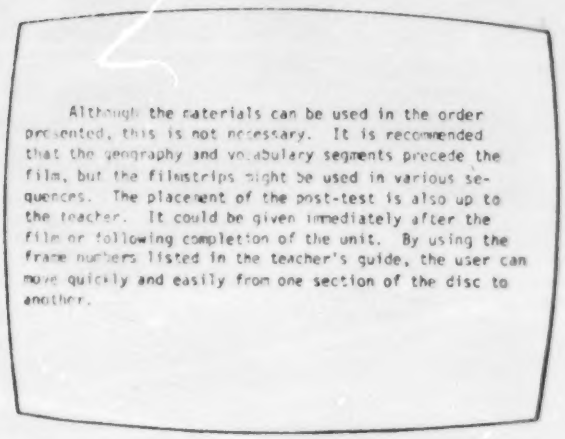
Although the materials can be used in the order presented, this is not necessary. It is recommended that the geography and vocabulary segments precede the film, but the filmstrips might be used in various sequences. The placement of the post-test is also up to the teacher. It could be given immediately after the film or following completion of the unit. By using the frame numbers listed in the teacher's guide, the user can move quickly and easily from one section of the disc to another.

Figure 2

Example of Typed Page for Videodisc Display

If visual and verbal information are to be combined in a still frame both elements must be considered individually as well as in relationship to each other. Electronically generated print insures legibility, but it also places strict limitations on the writer. With a 24 point font it is generally best to limit display to a maximum of eight lines of 26 characters each. Different type fonts will, of course, necessitate different parameters. Whatever font is used it is best not to fill the screen completely because the videodisc appears to crop the edges slightly. It is also best to assume that the completed disc will be played on monitors with some degree of cropping one one edge or another.

When the maximum amount of print is displayed on the screen the picture becomes virtually obliterated. Therefore the amount of verbal information must be balanced with the importance of the visual information. When the picture carries the bulk of the message the printed material should generally be limited to two lines. However, if the picture is used to supplement the text, five and six lines of print can be used provided that those lines are not too dense. If a picture has been seen previously and is used only as a recall device, it can be covered with more print than if it is being shown for the first time. The content has already been processed.

Placement of print over pictures must also be considered. Although captions are generally placed in the lower third of the screen, it is essential that the text not conceal that portion of the picture which carries the message. Print can be placed in various areas of the picture as labels

or to denote a speaker. And if the picture is essentially vertical the text can be placed in the other half of the screen. In short, the text can go almost anywhere as long as it does not interfere with the visual information being presented.

Research indicates that white captions are most effective (O'Bryan, 1975), but other colors can be used effectively for emphasis. Whatever color is used, a black outline should be added to enhance readability, and the placement of the text over a similar colored background should be avoided whenever possible. With a little practice it is relatively easy to remember that the area of the picture over which the text will be placed should not be white and that a color-highlighted word should not fall against an object of the same color. If it is not possible to avoid putting the verbal information across a sandy beach or some similar picture, the background under the caption can be shaded electronically. (See Chapter 5 for a further discussion of captioning.)

Instructional Units

There are different types of self-contained instructional units that can be used with videodisc instruction. First, the videodisc's ability to carry stills and motion means that it can simulate multi-media productions. It can include filmstrip or print units (stills) along with motion presentations. For example, a "film" can be supported by print and filmstrip-type supplemental materials, all of which are mastered on one disc.

Another type of instructional unit relates to instructional strategies. A disc can be designed so that after completing an instructional sequence the user can choose to continue, view more examples, view more practice items, or take a quiz. The examples, practice items, etc. are another type of unit which can be accessed by the user.

If several separate units of motion and/or still instruction are to be placed on one disc, certain equipment requirements come into play. Differences exist between the home and E/I model as to how material can be accessed and consequently, how such sequences should be designed. The home model has two indexing systems, one using individual frame numbers and the other using chapter numbers. The index button is pushed once for a frame read out and twice for a chapter display. Using the frame display, a user can manually search and step through the instruction until reaching the desired frame number. However, chapters can be more easily located using the chapter indexing system. In chapter display mode, depressing the search button causes the player to advance to the next chapter and automatically stop. The search proceeds in intervals of approximately 400 frames, meaning that each chapter opening requires a 400-frame window. The title or chapter beginning should be held for 400 frames or approximately 13 seconds to insure that the search will terminate on the opening.

The E/I player's random access capabilities eliminate the need for chapter stops. The user simply enters the appropriate frame number to move the laser beam to the exact location of the desired frame; no window is needed.

Scripting for a disc that includes motion and still sequences can follow traditional storyboard procedures for preparation of television and filmstrips, with the exception that scripts for the home model should specify a 400-frame window at the beginning of each chapter or unit. In addition, the producer must be provided with a sequence sheet that specifies how everything is to be edited together, including the amounts of black to leave between sections (Figure 3). In MDPHI's early experience with sequence forms an attempt was made to account for frame numbers. However, this idea was aban-

Contents of Israel Videodisc

Material & Sequence	No. of Frames	Cumulative Frames	Approximate Time	Approximate Cumulative Time
1. Teacher information (single frames)	3	3		
2. Black	5	8		
3. Teacher lesson guide (single frames)	8	16		:01
4. Black	150	166	:05	:06
5. Introduction	1350	1516	:45	:51
6. Geography lesson	1710	3226	:57	1:48
7. Vocabulary	10,980	14,206	6:06	7:54
8. Black	300	14,506	:10	8:04
9. Film	27,900	42,406	15:30	23:34
10. Black	450	42,856	:15	23:49
11. Related activities (single frames)	4	42,860		
12. Black	5	42,865		
13. Geography filmstrip (single frames)	35	42,900	:01	23:50
14. Black	5	42,905		
15. Jerusalem filmstrip (single frames)	51	42,956	:02	23:52
16. Middle East Update (single frames)	57	43,013	:02	23:54
17. Quiz (single frames)	50	43,063	:01	23:55
18. Black	5	43,068		
19. Funding information (single frames)	1	43,069		
20. Branching frames (single frames)	50	43,119	:02	23:57

Figure 3

Example of Videodisc Sequencing/Editing Information for Producer

doned when the difficulty of the task become obvious. Translating SMPTE time code into frame numbers should provide an accurate method of frame counting. However, since MCA does not have the facilities to read time code and cannot zero reference with tape masters, at present there is no assurance that the frame numbers will match.

Including several instructional units on one disc requires a referencing system to help the user locate materials. An example of an index is shown in Figure 4. This particular indexing system lists frame numbers and execution buttons users need to locate materials and initiate their playback. Brief descriptions of each sequence could be included so that teachers can select materials appropriate for their class. A similar index (without frame numbers and descriptions) could also be placed at the head of the disc itself, with individual sections being preceded by still frames showing that section's contents and objectives.

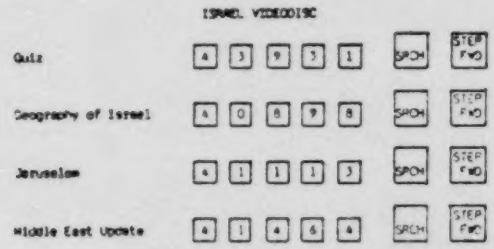

Figure 4

Example of Videodisc Index for User

Integration of Motion and Stills

The random access and chapter stop functions of the two MCA videodisc models make it relatively simple to include separate units of motion and still frames on one disc. Mixing motion and stills within the same unit, however, presents a more difficult problem: the automatic stop.

Since each still frame requires only 1/30 second real time, in moving from motion to stills the player must be stopped and the stills freeze-framed. Manually stopping the player is impossible since a person's reaction time is longer than 1/30 second. Moving from motion into stills can only be achieved if the player automatically stops at a precise point.

There are differences between the two players regarding automatic stop. Under the existing technical configuration, auto stop on the E/I player can only be achieved through some programming function entered either through the videodisc's remote control unit or through a computer program. This type of auto stop function limits user control. If the user chooses to stop, search, or slow down the instruction while the disc is in the program mode, all programmed functions are lost. In other words, the disc would no longer stop at the next programmed auto stop. To maintain programmed functions the user must proceed through the disc according to the predetermined computer program.

Auto stop on the home model, on the other hand, can be achieved by a series of audio tone cues recorded on the disc itself. During playback, the disc will automatically stop when it encounters these cues. The E/I player will not respond to tone cues.

But what happens if a designer wants one disc to play on both the home and E/I player? When there is playback compatibility between the two players, perhaps the best solution is to avoid auto stops all together. One possibility is following motion sequences with about three seconds of STOP MOTION frames, requiring the student to depress the STOP (E/I player) or STILL FRAME (home player) button. He/she would then use the single frame forward button to reach the still frames. The problem with this strategy is that, depending on a student's reaction time, he/she could have a large, undetermined number of still frames to step through. To avoid this problem, an alternative solution is to use a combination of

STOP MOTION and accompanying frame reference indexes. The STOP MOTION frames would instruct the student to refer to the print index for the address of the next still sequence. Ideally, of course, the index numbers would be on the STOP MOTION frame itself. However, as mentioned earlier, accurate prediction of each of the videodisc's 54,000 frames before mastering is next to impossible. Especially critical are still frame sequences, for calculations must be frame accurate. A one-frame error can cause confusion.

The technically-oriented auto stop problem has a definite influence on designing sequences with stills and motion, but there are other considerations. For one, the designer must carefully balance the motivational and interest arousing characteristics of film and television with the more pedantic, programmatic characteristics of the single frame. Adding still frames in the middle of a motion sequence requires careful consideration of transitions and pacing. Still frame sequences must be carefully planned to reinforce or extend the motion sequences, possibly providing practice problems or inserted questions, without abruptly interrupting the continuity of the presentation.

The designer should remember that although still frames are de-emphasized in terms of real time allotment on the disc, they can in fact be given a great deal of instructional emphasis. The key is having the user stop at that point for greater study or even note taking. If necessary, the player can be automatically stopped at any given point to force the user to linger and study the visual in greater detail. What the still frame and stopping capabilities lead to are a more rapid real time presentation of material. There is no need to slow the pace of the program to match the slowest learner. "Fluff" pieces are also no longer necessary as a way of allowing some absorption time.

Another consideration in designing programs that integrate stills and motion is that certain conventions are needed so that the viewers can easily tell where they are and what they should do. For example, when a user is supposed to step through a series of still frames, the command at the bottom of each frame is STEP FORWARD. At the end of such a sequence there are additional instructions or a command to PLAY if the user is to view a subsequent motion sequence. There may be other control instructions depending on how the material is arranged and how much automatic control is provided by the player or an attached computer.

Storyboarding

The authoring procedures for videodisc productions that combine motion and stills within the same sequence differ from traditional television or film methods. Typical storyboard forms with only video and audio columns are inadequate to account for the type and amount of videodisc instruction.

Disc programs can contain hundreds of motion and still segments, translating into a similar number of edits. Making sure that all the segments are in the correct order with pictures, captions, and audio information syncronized is a mammoth task. Because of the tremendous amount of material that can be placed on one disc and the difficulty of assembling and keeping track of all sequences, it is important to use very specific storyboard forms.

MDPHI currently uses a four column storyboard based on Bennion's videodisc format (Bennnion, 1976). Two columns deal with the video material while the other two columns are necessary for explication of the two audio tracks (Figure 5).

The first column describes the visual that will be seen on the monitor. This can be done pictorially

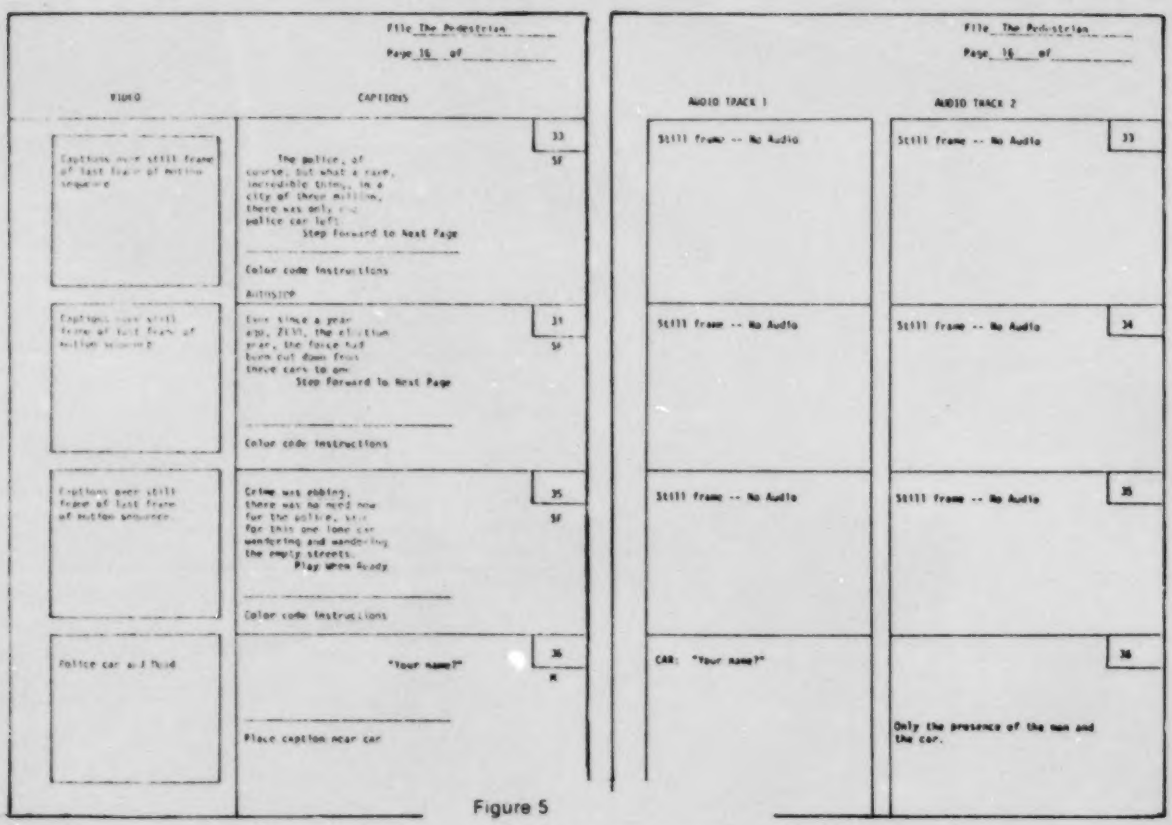

Figure 5

Videodisc Storyboard Forms

with drawings or verbally through written descriptions. If the video remains the same while other elements change, the boxes in the first column following the initial descriptions are left blank. Where textual material will be presented, either on still frame or motion sequences, the content is written in the second column. This could include direction frames, test sequences, or captions accompanying other visual material. This text should be written out explicitly just as it will appear in the final product, and each single frame should occupy a single box.

Each segment is numbered in the upper right hand corner of the second column, and each new segment indicates an edit in the visual material. During actual shooting the producer titles (slates) each segment with its storyboard number. If material is shot out of sequence, this greatly simplifies the editing and minimizes errors.

It is, of course, also essential that the producer understand which segments are intended as motion and which are single frames. Beneath the segment number the type of sequence is described--either motion, single frame, or window. Motion and single frames are self explanatory. Windows occur when the videodisc player needs some leeway in locating where it is supposed to stop, such as chapter stops on the Magnavision player.

The second column also contains instructions to the producer. These are located at the bottom of the box, where applicable, and are separated from any textual material by a solid line. Instructions could include fade outs or lengths of time to hold particular sequences, or they could be directions for the operator of the character generator, such as font size, color coding, or text placement. Auto stop or chapter stop instructions would also be included here.

The two audio columns are dealt with in a more traditional manner. Each column merely spells out what will be on each track. However, it is important to keep the segments lined up with the corresponding video sequences. To facilitate this matching small boxes in the upper right corner of the second audio column are used. The design/production team then need only make sure that the numbers match up with the video page. It is also important to remember that still frames have no audio, and sequences designed for play in slow motion will lose their audio on both the home and E/I models. Window sequences can have audio tracks but chapter stops cause the user to land anywhere within a 400-frame window. He or she would then usually play through the rest of the window and continue playing the next sequence. Therefore, although the last part of a window's audio track might be heard by most users, the first part would probably be heard by few.

Whatever storyboard format is used, the many diverse elements of a videodisc program must be clearly delineated. Audio and video, single frame and motion, and the two audio tracks must be kept separate and discernable. But the many individual parts must also be clearly and carefully indexed so they can be edited together in their proper sequence.

Interactive Instruction: Multiple Choice Branching

Interactive instruction can be achieved through the use of the E/I player alone or through computer interface with either the E/I or home models. If using the E/I player, programming information is entered through the remote control. The player can be programmed to respond to student's input and initiate simple branching. Previously discussed was the possibility of including additional practice items, examples, or quizzes that the user could access manually, if desired. It is also possible to use branching techniques to direct students to appropriate disc locations. After completing an instructional unit a user could select his/her next option by pushing one button, i.e. 1 to continue, 2 to access more examples, 3 to review, etc. In preparing such branching networks care should be taken to avoid paths that terminate without allowing the user to return to the mainstream instruction.

Branching can also proceed from student response to content questions. Figure 6 shows a simple branching network prepared for a testing sequence. The numbers in rectangular boxes are frame numbers; the numbered arrows represent student response 1, 2, 3, or 4. A student views a question frame (43,931) and inputs 1, 2, 3, or 4. If the answer is correct (4), he/she is advanced to a confirmation frame and then can proceed to the next question (43,935) by pushing 0. If the answer is wrong (1, 2, 3) the student is branched to a frame indicating the response was incorrect (44,481). By pushing 0 he/she is then returned to the instructional sequence itself for review (14,564 - 14,776) before proceeding to the next question.

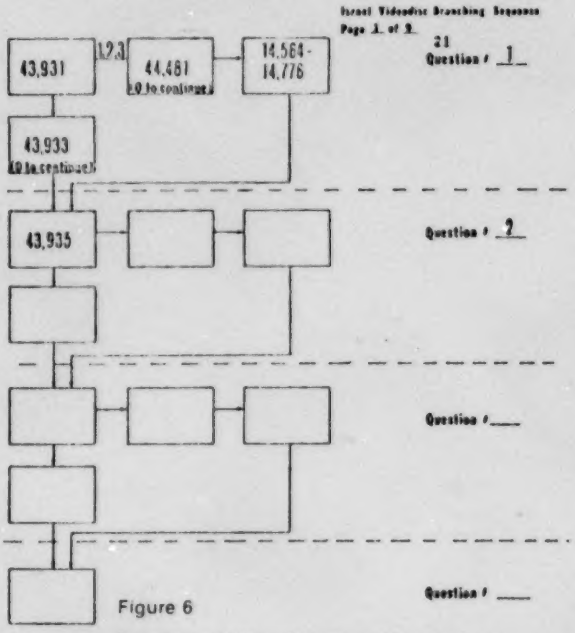

Figure 6
Example of Videodisc Branching Sequence

Registers	Frame Number
0	43,931
1	43,933
2	44,481
3	14,564
4	14,775
5	43,935

0	0	21	Recall	42	5
1	Recall	22	Search	43	Recall
2	Search	23	1	44	Search
3	5	24	Input	45	End
4	Input	25	3	46	
5	2	26	Recall	47	
6	0	27	Search	48	
7	Branch (Run)	28	4	49	
8	2	29	Recall	50	
9	0	30	Auto Stop	51	
10	Branch (Run)	31	1	52	
11	2	32	0	53	
12	0	33	Stop	54	
13	Branch (Run)	34	4	55	
14	2	35	2	56	
15	0	36	Branch	57	
16	Branch (Run)	37	1	58	
17	3	38	Recall	59	
18	7	39	Search	60	
19	Branch (Run)	40	1	61	
20	2	41	Input	62	

Figure 7

Sample Program for E/I Player

The program written for this sequence is found in Figure 7. Including the register numbers, it required 93 keystroke entries and represents the branching sequence for only one question. MOPHI's experience in writing and running such programs revealed that manually programming the E/I player was unfeasible; it is a difficult and time consuming task. Since there is no way to externally store programs on floppy disc or audio cassette, it becomes necessary to reprogram the player virtually every time a user wants to make use of the disc. There is also the limitation of the E/I player's memory, 1024 keystroke entries. Complex branching situations can easily exceed this capacity.

A more desirable programming method is to encode the programming at the head of the disc during mastering. The programming information is fed into the videodisc's microprocessor when the player is activated. No external computer is needed, and no manual programming is required. However, the momory capacity of the DiscoVision player is limited, and, again, input from the user must be in the form of digits, not letters or commands (i.e. PLAY, STEP FORWARD, etc.).

Branching sequences with the videodisc can also be achieved through interface with a microcomputer. This configuration provides a stand-alone CAI system with the user responding through the computer keyboard. Such a system provides greater memory capacity and supports more complex branching networks. An advantage is that a program can be placed on audio cassette or floppy disc and distributed with the disc for ease in program playback. In addition, commands to continue, etc. can be initiated by the user entering letters (i.e. "C") instead of numerics ("0").

The sequence of materials on a videodisc designed for CAI does not need to be the same as the sequence in which the user will view those materials. Indeed, it would rarely be advantageous to produce a CAI videodisc in a linear format. Since the player is connected to a microcomputer, it is more economical to let the computer determine the sequencing of the many individual segments. In this way the same segments, or units, can be used repeatedly in various sequences or formats. The ability to search out individual frames in a matter of seconds makes the videodisc an ideal medium for this sort of strategy. And to exploit this advantage to its fullest, those frames most frequently used in branching sequences can be placed in the middle of the program. This reduces the average search time that much more because the maximum search distance is only one half the program.

One videodisc could be programmed for both teaching and testing sequences by rearranging various teaching segments in combination with direction, question and feedback frames. A unit designed for videodisc CAI could include teaching sequences followed by different types of testing sequences, such as right-wrong or multiple choice. Segments from the initial teaching sequence could be re-used in the testing sequences, thereby saving valuable disc space, and additional segments could be accessed from throughout the disc as needed.

If the disc were played straight through in a linear fashion the student would see segments from the instruction sequences interspersed with segments from the testing sequences, while direction and feedback frames might be lumped together in a seemingly random manner. When programmed, however, the computer would sort out the necessary segments for each part of the lesson and present them in sequence (Figure 8). A multiple choice test, for example, might include segments from the previous teaching segments, as well as new segments never before seen. And the progression

Teaching Segment: This segment is predominantly linear with only a few still frames at the very beginning. However, the student does have the option of stopping the segment manually at any time and repeating a sequence he or she does not understand.

... D-3 - D4 - 8 - 9 - 14 - 15 - 19 - 20 - 21 - 22 - 25 - 26 - 27 - 28 - 31 - 33 - 34 -

37 - 38 - 41 - 42 - 45 - 46 - 47 - 48 - 51 - 52 - 63 - 64 - 67 - 68 - 71 - 72 - 75 - 76 - ...

Multiple Choice Segment: Each group of numbers represents one sequence. The arrows following the sequence show the three possibilities depending on the student's response. Arrow A represents a correct response; B represents an incorrect response; and C represents a lack of response.

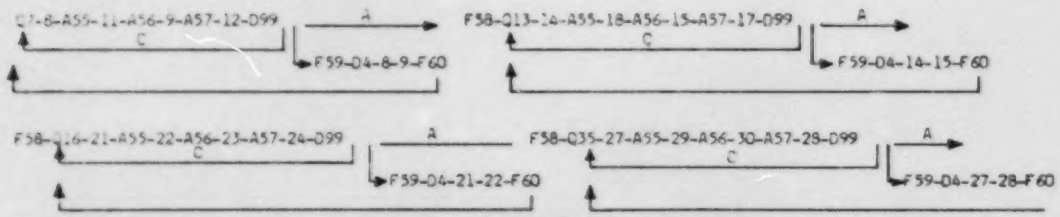

Figure 8

Diagram for Program

The two diagrams illustrate the sequence in which materials might appear to a student using a disc in a CAI situation. The numbers refer to the storyboard sequence numbers and can be either single frame or motion sequences. Numbers preceded by D indicate direction frames; Q, question frames; A, alpha-numeric frames for multiple choice segments; and F, feedback frames. All other numbers indicate teaching sequences.

through the test could also be determined by the student's response. If the answer was correct the student might get a positive feedback frame and another question. If the answer was incorrect the student might see a correction frame, a direction frame, and a review of the initial instruction sequence before having the question repeated. And if the student did not respond at all within a set time period, the question could be repeated.

When working with branching sequences certain television editing conventions come into play. In preparing sequences moving from still frames into motion, the designer must remain cognizant of production considerations such as pacing and transitions. If certain sequences are to be used for both teaching and testing, care must be taken to assure that their integration into both contexts is visually smooth. For example, motion sequences may need to begin or end with a two to three second transition such as a fade or freeze frame. Designing branched instruction using the pictorial capabilities of the videodisc can become a lesson in computer editing.

Interactive Instruction: Branching from Constructed Responses

To achieve interactive instruction with student input in the form of constructed responses (fill in the blank, etc.) the videodisc must be interfaced with a computer. Character string responses are only possible with the addition of a microcomputer component. Other elements, such as scorekeeping, can also be achieved under this configuration. Interactive and instructional strategies are limited only by the ingenuity of the design team and the type of computer interface initiated. Bennion (1976) has described several possibilities, some utilizing strategies common to TICCIT.

THE TEAM CONCEPT

The design/production team for the MDPHI project includes an instructional designer, a scriptwriter, and a producer-director. In addition,

technical advice is provided by an engineer from Nebraska Educational Television who is assigned to the videodisc project. The nature of videodisc development required the use of a design model based on a team approach. A pass-on system, where the instructional designer prepares a design to give to the scriptwriter who writes a script to give to the producer, was clearly inappropriate. Because there are production problems unique to the videodisc, the producer needs to have continual input to assure that the design and final script is producible.

An examination of the storyboard forms provides evidence of the explicitness demanded at the script stage. As videodisc production moves from linear programming to CAI, the scripts become less like their television forebearers. There is a greater need for specificity, and the use of storyboards means that there are few generic visuals specified in the video column and more specific editing and assembly instructions. Everything is clearly spelled out, leaving little room for producer discretion and editing. Because of the production elements which must be reflected in the storyboard, it is important for the producer to be involved throughout the design process. The result is a merger of instructional and production design. The two are unified; the production is not superimposed later as a distinct function.

But just as the producer is more involved in the design, so is the designer more involved in production. Despite the fact that videodisc storyboards specify exactly what is to be displayed, the sheer volume and complexity of information and its assembly means that editing is a mammoth task. It is unrealistic to assume that one person (the producer) can be totally responsible for material assembly. MDPHI currently uses a three person post-production team--the producer, a production assistant responsible for generating still frame captions, and either the designer or scriptwriter to follow the storyboard script and serve as a proofreader. The presence of the designer or scriptwriter at editing means that production and design personnel are involved throughout the entire process. No one really "drops out" at any point, although each person has primary responsibility for his or her specific area of expertise.

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CHAPTER 5: Videodisc Production

A videodisc can be mastered from any videotape or film source. MDPHI, through the facilities at Nebraska ETV, is producing all programs on two-inch quadraplex tape. Production could be on 16mm film, but for cost and time considerations, the production staff has chosen videotape.

EDITING

All editing is done electronically using a Central Dynamics computer controlled editing system. This system utilizes SMPTE time code that is laid on to the tape. The time code can be made visible on tape copies so that the exact location of any piece of material can be determined. The final program tape also has a time code which allows exact control of material assembly. Edits accurate to a single frame are possible, and long sequences where each part is only one frame can be built up. Videotape assembly of programs with single frame sequences would be impossible without such a system.

There are two problems with videotape assembly using such equipment. First, single frame sequences must be recorded in order from beginning to end. Changing any one frame is impossible without relaying all of the frames that follow it in sequence. This procedure is necessary because the system will not record just one frame; it actually records three to four. In trying to replace one frame in a sequence, two to three of the following frames will be destroyed. This problem can be overcome, however, if all of the frames are generated from one or two videotapes. The computer editor has a continuous mode and can be programmed to lay down long sequences automatically. MDPHI production staff has built up single frame sequences as long as 70 frames in less than 20 minutes in the automatic (continuous edit) mode. Tape wear can become a problem if the same material is relaid several times, however. There is also a problem with the quadraplex machines. Since freeze frame with such machines is impossible, there is no way to view single frames. When played in real time, a single frame sequence is a flash of images. This problem can be circumvented by transferring the completed sequence to one-half inch helical videotape. With the half-inch player in the pause mode, it is possible to "walk" the tape by manually turning the reels. This procedure gives an accurate, if primitive, look at each frame. The use of one-inch helical scan broadcast quality machines would overcome both the single frame recording and viewing problems, and the engineering staff at Nebraska ETV is currently testing such systems for application to videodisc production.

Computer control has another advantage in that a punch tape and print copy of all edit times is provided after the program has been assembled. These can be used to re-program the computer so that any changes can be made quickly.

Dual-channel audio is accomplished by first assembling the full program with one sound track. This track is then dubbed off and the second track is built up, timed from the primary track. The two tracks are then laid back onto the program tape with a dual-channel audio head.

CAPTIONING

All captioning is done with an electronic character generator, which provides very clear captions. A dark

transparent background can be added behind the captions to make them even more readable. A soft-edge keyer is used to blend the darkened area into the picture. This makes the background less harsh and more like an integral part of the original picture.

Time code editing facilitates the captioning of motion sequences. An A-B roll technique is used. The program is first mastered without captions and a copy is made with a visual display of the time code. This copy is then used to create a very accurate log of where each caption is to be placed. Using the log, the producer prepares a videotape with only the captions on a black background. Finally the caption tape is mixed with uncaptioned master to create a third tape with the program material and captions.

Print graphics are also created with the character generator. An electronic character generator is a practical necessity to construct direction frames and still frame sequences that require extensive captioning. There can be hundreds and even thousands of such frames in a complex videodisc program. and the creation of graphics on cards or slides would be a major burden and expense. With the character generator it is possible to create and view all of the print as fast as the operator can type. Changes and decisions about size and color of lettering can be made very quickly. All print graphics can be done off-line and stored on a floppy disc for later insertion into the program. The electronic characters also provide a quality and readability not easily attained with graphic cards or slides.

PRODUCTION CONSIDERATIONS

In medium like the videodisc where the viewer may skip, repeat, stop or slow down the presentation, the pacing of material can be very different from normal, real-time television. For example, in a traditional program the producer will often slow down the pace, repeat certain elements or even all segments that are not hard content in order to give the viewer some absorption time. Such additions are not always necessary with the videodisc as the viewer has a lot more control. Also, with the ability to add problem solving sequences, definitions, explanations and quizzes, all as a series of still frames, the motion sequences can be relegated to demonstrations or explanations that require motion, they need not carry all of the burden or the instruction. As a result, the motion sequences on a videodisc may seem very fast paced. Keep in mind that the viewer is in control and can repeat any given segment as many times as needed to understand the content.

Videodisc programs may as a result not be as "pretty" as traditional programs, but hopefully they will be more effective.

The key factor in production of programs that take real advantage of the videodisc's capabilities is the "control" factor. The producer can control each of the thousands of frames that make up a program giving him/her much greater choice in deciding how material will be presented. It also means that the production equipment must be able to control, frame by frame, the assembly of a program.